REMARKS/ARGUMENTS

Status of Claims

Claims 1, 3, 4, 7-11, and 14-16 are pending in this application, with claims 1 and 8 being independent. Claims 1, 3, 4, 7-11, and 14 have been amended. Claims 15 and 16 have been added.

Support for new claims 15 and 16 may be found in the specification, for example, in original claim 8 and at page 7, line 36 – page 8, line 2 and page 12, lines 17-28.

Overview of the Office Action

Claims 1, 3, 4, 7 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Jeanne et al. "Source and Joint source-channel decoding of variable length codes" ("Jeanne") in view of U.S. 6,128,765 ("Ross") and 6,812,873 ("Siohan").[1]

Claims 8, 10, 11 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Garcia-Frias et al., "Joint Turbo Decoding and Estimation of Hidden Markov Sources" ("Garcia-Frias") in view of U.S. 20060053004 ("Ceperkovic"). Claim 14 has been rejected as being unpatentable over Garcia-Frias in view of Ceperkovic and Jeanne.

The Office Action states that claim 9 would be allowable if rewritten in independent form.

[1] Applicants note that Ross and Siohan are not mentioned in the statement of the rejection at the beginning of paragraph 4 of the Office Action, but the Examiner relies on these references in the detailed discussion of the rejection. Applicants further note that the Examiner has not explained why one of ordinary skill in the art would have combined the teachings of these references with Jeanne and, thus, the Examiner has not fulfilled the requirements for establishing *prima facie* obviousness.

Summary of Subject Matter Disclosed in the Specification

The following descriptive details are based on the specification. They are provided only for the convenience of the Examiner as part of the discussion presented herein, and are not intended to argue limitations which are unclaimed.

As discussed in the specification, digital communications systems may use both source coding and channel coding systems. For example, Figure 1 of the present application depicts the transmission of digital data from a sender (source 10, source encoder 20, and channel encoder 30) to a receiver having a decoder stage (combined source-channel turbo-decoder 50, VLC decoder 60) over a transmission channel (40).

The sender may include a source (10) of symbols (i, j, etc.). In a video coder, for example, these symbols may correspond to texture movement coefficients quantized to yield a certain number of discrete values. The source (10) may be followed by a video coder (20) that uses a variable length code (VLC) table to encode the symbols (i.e., that performs source encoding). Source encoding removes redundancy in the source in order to transmit a more compact, compressed representation of the information (this is advantageous as it reduces bandwidth, memory consumption, etc.). Source encoding may be followed by channel encoding, e.g., convolutional parallel turbocoding, of the digital data from the source encoder (20) to protect source encoded data against interference induced during its transmission over the channel (40). Channel encoding adds redundancy in such a manner that even if part of the transmitted information is corrupted, some of the redundant information may still be available (i.e., not corrupted) to reconstruct corrupted data.

Decoding of convolutional codes, such as turbocodes, typically involves a comparison of probability values for different paths in a decoding trellis. Such probabilities are referred to as *a*

posteriori probabilities, because they quantify the likelihood that the received channel encoded data (possibly altered during transmission) is one source encoded symbol or another and are <u>based on the received data itself</u>. In a combined channel-source decoding of digital data, it is also possible to use forward-looking probabilities to help make decoding decisions for digital data, which are referred to as *a priori* probabilities. *A priori* probabilities quantify the likelihood that <u>data yet to be received</u> is going to contain one symbol or another.

The embodiments of the invention described in the specification relate to a method of combined channel-source decoding of digital data. As shown in Figure 2 of the present application, the receiver includes a combined channel-source turbo-decoder (50) which may use, for example, a maximum *a posteriori* (MAP) decoding algorithm. Digital data is fed from the combined channel-source turbo-decoder (50) to a VLC decoder 60, e.g., an MPEG-4 video decoder, to supply at the output of the VLC decoder an estimate of the values of the symbols (i, j, etc.) from the source (10).

<u>Source encoded symbols are estimated</u> inside the combined channel-source turbo-decoder (50) from bits output by a convolutional channel decoder (51') of the combined source-channel turbo-decoder (50). The bits that are output by the convolutional channel decoder (51') are channel decoded, but not yet source decoded. Source encoded symbol estimation may be done by parsing the stream of bits and recognizing its structure (i.e., bit patterns corresponding to symbols). In particular, when the symbols are VLC source encoded symbols (i.e. their length varies from symbol to symbol), estimating the source encoded symbols can be carried out via a table-based VLC decoder (53) of the combined source-channel turbo-decoder (50), which is able to identify where each source encoded symbol starts and ends in the stream of bits.

The *a priori* probabilities of the source encoded symbols are estimated iteratively inside the combined source-channel turbo-decoder (50) by means of a histogram generator (54) and a module for calculating symbol probabilities (55). The histogram generator 54 can indicate the number of occurrences of each symbol or the number of transitions between particular pairs of successive symbols. The histogram generator (54) can therefore calculate probabilities of symbol occurrences, p(i), or probabilities of transitions between symbols, p(i/j).

A converter module (56) is provided for the conversion of symbol probabilities to bit probabilities using a VLC tree. The module (56) injects bit-level probabilities into the channel decoder (51). These probabilities are then inserted as *a priori* probabilities into a Max-Log MAP decoding algorithm executed on the trellis of the convolutional decoder (51), where they are used to improve the decoding of the convolutional code. This process resumes on the next turbocode iteration, thereby further refining the source symbol probabilities p(i) and p(i/j) and, consequently, the source *a priori* probabilities used for turbodecoding.

Descriptive Summary of the Prior Art

Jeanne

Jeanne discloses two different embodiments. In a first embodiment, described in Section III, Jeanne describes a method to decode entropy-coded sources that are corrupted by additive white Gaussian noise. There is no channel coding in the embodiment of Section III, but only source coding (see, e.g., Figure 1, and page 768, left column, last paragraph). In a second embodiment, described in Section IV, a channel coding consisting of a turbo code is implemented (see, e.g., first paragraph of Section IV and Figure 3), which changes the structure of the decoder. In both embodiments, Jeanne proposes a technique to obtain *a priori* bit

probabilities from *a priori* symbol probabilities of the source. *A priori* bit probabilities are used in a soft decoding procedure (see, next-to-last paragraph of Section I and Section II).

Jeanne explains that the symbol probabilities come either directly from the source or from an estimation algorithm, but does not provide further details on how symbol probabilities would be obtained (see Section II, first paragraph). Rather, Jeanne merely assumes that the *a priori* symbol probabilities are available. It is noted that Figures 1, 3 and 4 include an input arrow entitled "*a priori*" which comes from no particular source. In the simulation results of both embodiments, the decoder relies on tables (see Tables I and II, page 770) of pre-stored *a priori* probabilities (see, respectively, Sections III-C and IV-B).

In equation 12 (page 771), Jeanne shows how to compute *a posteriori* probability (APP) from *a priori* probability and other parameters. More specifically, equation 12 relies on extrinsic information $Ext(d_l)$. Jeanne, at page 771, left column, last paragraph of Section IV-A, explains that computation of the extrinsic information $Ext(d_l)$ is required, without indicating how to compute it. Equation 11, which leads to equation 12, shows that extrinsic information $Ext(d_l)$ includes the parameter $P(d_l|VLCTree)$, which corresponds to the *a priori* source probability (page 770, left column, first two lines, and page 771, right column, second paragraph).

Siohan

Siohan relates to a method for decoding data coded with an entropic code. At column 2, lines 63-65, the portion cited in the Office Action, Siohan states: "It must be noted that the general decoding scheme of the turbo-codes is the same, whether block turbo-codes or convolutional turbo-codes are used." However, the next sentence states that "The difference lies in the interleaver and in each of the two decoders DEC1 and DEC2".

Ross

Ross discloses forward and backward recursive calculations in a maximum *a posteriori* decoding process which are performed in parallel processes, rather than sequentially, allowing *a posteriori* transition probabilities to be calculated in the same time interval as the recursions, thereby reducing decoding latency and required memory.

Garcia-Frias

Garcia-Frias relates to a joint source-channel scheme for modifying a turbo decoder in order to exploit the statistical characteristics of hidden Markov sources (Abstract). Garcia-Frias attempts to model the received bits with a hidden Markov source. A hidden Markov source according to Garcia-Frias has N possible states S_i (i=0...N-1), and outputs a bit v ($v \in \{0,1\}$) the value of which depends on the current state of the hidden Markov source and on a probability rule. The hidden Markov source is completely specified by a set of three parameters A, B and π, where A/B are probability matrix/vector which size depend on the number of states, and π is the initial state distribution vector (see page 1671, last two lines of left column to first paragraph of right column).

According to Garcia-Frias, the parameters (A, B, and π) characterizing the hidden Markov source can be either pre-stored in the joint decoder, or estimated by using the noise-corrupted observations, see in particular page 1674, Section III, first nine lines. Then, once the hidden Markov source (source block S on Figure 3) is properly modeled, the constituent turbo decoders (D_0, D_1) provide an *a posteriori* bit probability of the previously received bit to the hidden Markov source block S, which accordingly provides an *a priori* probability of the next bit, in order to assist the joint decoder in determining the actual value of this bit (Figure 3 and page 1672, last paragraph of left column).

Ceperkovic

Ceperkovic relates to methods and apparatus for data compression and decompression and, more particularly, still and moving image lossless and lossy compression and decompression (paragraph [0001]). Figure 3 and paragraph [0070] disclose decompression by a decoder 31. An input compressed image 19 is received by an entropy decoder 29. The output 15 of the entropy decoder 29 is received by a decoding probability estimator 27, in order to reconstruct the symbol probabilities 17. Ceperkovic purports to provide improved decompression through a symbol probability estimation using a minimum number of histograms (paragraph [0003]). Paragraph [0153] and Figure 35 explain how such histograms are managed. The histograms are used to determine the symbols composing the compressed image.

<u>Patentability over the Prior Art</u>

Amended independent claim 1 recites, *inter alia*: "estimating the source encoded symbols from bits output by a convolutional channel decoder of the combined source-channel turbo-decoder;" and "statistically estimating, at each iteration of the combined source-channel turbo-decoder, a priori probabilities from occurrences or transitions of the estimated source encoded symbols". These features may be understood by referring, for example, to Figures 2 and 3 of the specification and to the discussion above regarding the histogram generator (54), the module for calculating symbol probabilities (55), and the converter module (56) for converting symbol probabilities to bit probabilities using a VLC tree.

Jeanne, on the other hand, <u>pre-stores</u> *a priori* probabilities of symbols (see pre-stored tables I and II, page 770). Jeanne states that it would be possible to estimate *a priori* symbol probabilities (Section II, first paragraph) without having to pre-store them, but does not disclose any way of doing so. As discussed in the specification, certain probability estimation techniques

were known at the time of the present application, and these techniques can be divided into two categories, i.e., categories (c) and (d), as explained from page 3, line 4 to page 4, line 9 of the specification. However, these prior art techniques are substantially different from the claimed estimation technique.

Ross and Siohan were cited as purportedly disclosing the certain aspects of convolutional coding. However, nothing has been found in these references that would remedy the deficiencies of Jeanne with respect to the features of claim 1 discussed above.

Accordingly, claim 1 is deemed to be patentable over the combination of Jeanne, Ross, and Siohan.

Amended independent claim 8 recites, *inter alia*: "means for estimating source encoded symbols from bits output by the convolutional channel decoder;" and "means for calculating said a priori probabilities (p(i), p(i/j)) associated with said estimated source encoded symbols".

Garcia-Frias, by contrast, discloses a method that operates directly at the bit level, rather than using symbol probabilities. In particular, the decoding method disclosed in Garcia-Frias involves parametric estimation of a source. This sort of parametric estimation is discussed in the Background section of the present application (see, category "(c)" at page 3, lines 4-19).

In the parametric estimation technique disclosed in Garcia-Frias, a hidden Markov source model (see source block S in Figure 3) is first created and then certain parameters (i.e., probability matrices/vectors A, B and π) are computed that characterize this model. Then the constituent turbo decoders (D_0, D_1) of Garcia-Frias provide an *a posteriori* bit probability of the previously received bit to the hidden Markov source block S, which accordingly provides an *a priori* probability of the next bit, in order to assist the joint decoder in determining the actual value of this next bit (see Figure 3 and page 1672, last paragraph of left column).

However, Garcia-Frias does not envision estimating source encoded symbols (i.e., the structure of the bit stream induced by the source encoding is not considered). Rather, Garcia-Frias merely sends the next available *a posteriori* estimated bit to the hidden Markov source block S, which in turn determines the next bit *a priori* probability.

In addition, as acknowledged in the Office Action, Garcia-Frias fails to disclose "a generator of histograms of occurrences or transitions of the estimated source encoded symbols" as recited in claim 8.

The Office Action contends that one skilled in the art would have combined the teaching of Garcia-Frias with Ceperkovic to include a histogram generator in the channel decoding process. However, the histograms of Ceperkovic and the histogram recited in claim 8 serve completely different purposes and are located in different places in the decoding chain. Ceperkovic deals with data compression/decompression, but does not address the issue of erroneous bits being introduced, in the context of channel encoding/decoding. Therefore, one skilled in the art would not have turned to the histograms disclosed in Ceperkovic to improve channel decoding.

Accordingly, claim 8 is deemed to be patentable over the combination of Garcia-Frias and Ceperkovic.

Claims 3, 4, 7, 9-11, and 14-16, which each depend from one of independent claims 1 or 8, distinguish the invention over the applied prior art for reasons discussed above in regard to the independent claims as well as on their own merits.

Conclusion

Based on all of the above, the present application is now in proper condition for allowance. Prompt and favorable action to this effect and early passing of this application to issue are respectfully solicited.

It is believed that no additional fees or charges are required at this time in connection with the present application. However, if any additional fees or charges are required at this time, they may be charged to our Patent and Trademark Office Deposit Account No. 03-2412.

Respectfully submitted,
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Dated: September 24, 2010